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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

D. W. MAY, Special Agent in Charge.

Mayaguez, March, 1912.

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Suggestions on Coffee Planting for Porto Rico.

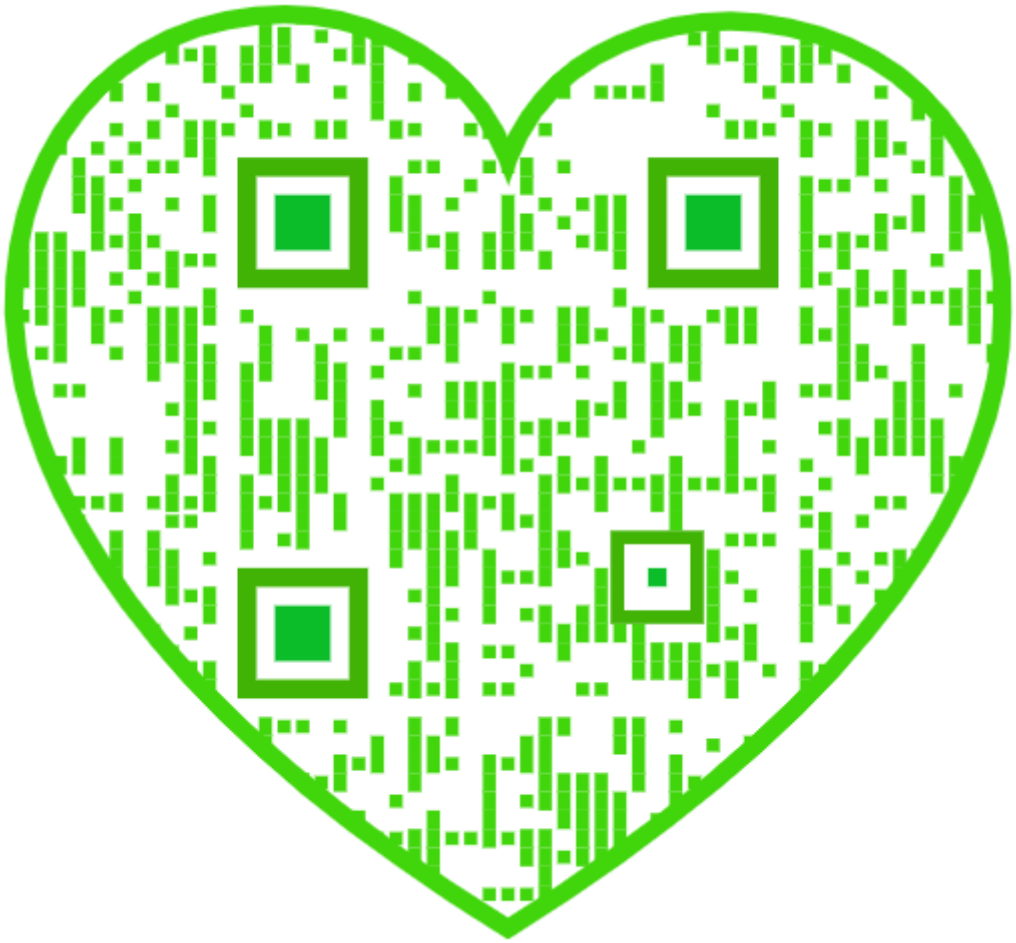
BY

T. B. McCLELLAND,

Assistant Horticulturist.

UNDER THE SUPERVISION
OFFICE OF EXPERIMENT STATIONS,
U. S. Department of Agriculture.

MAYAGUEZ, P. R.
PRES. LA BANDERA AMERICANA.
1912.



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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

(Under the supervision of A. C. TRUE, Director of the Office of Experiment Stations, United States Department of Agriculture.)

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Withdrawn
8/12/18

LETTER OF TRANSMITTAL

Porto Rico Agricultural Experiment Station,

Mayaguez, Porto Rico, March 31, 1912.

SIR: Coffe growing in Porto Rico will continue as one of our leading industries. This is due not only to the adaptation of many of our lands both by composition and location, but to the excellence of the product.

The edition of our circular No. 5 by J. W. van Leenhoff has been exhausted and it is advisable to issue another in lieu thereof which will embody some later results of our investigations with this important crop.

Respectfully,

D. W. MAY,
Special Agent in Charge.

DR. A. C. TRUE,
Director, Office of Experiment Stations,
U. S. Department of Agriculture, Washington, D. C.

Recommended for publication.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

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Suggestions on Coffee Planting for Porto Rico.

INTRODUCTION.

The extreme limits of coffee cultivation extend slightly beyond the tropics. Porto Rico is located well within them, however, lying between parallels 17°54' and 18°30' north latitude.

The greater part of the Island is mountainous, the formation being largely of igneous and volcanic rocks. (1) These mountains vary in altitude from the low foot hills to peaks 3500 feet high. They are deeply eroded and consist of numerous peaks and ridges. Although the Island has many excellent roads yet there are of necessity many sections which must depend on trails and pack animals for transportation of their produce to main road, railroad, port or market. On account of delays and difficulties which arise from such conditions of transportation in many localities the growing of such perishable crops as might otherwise be very profitable must meet with failure until better facilities for transportation are provided. Something must therefore be grown which will be injured by neither a little delay nor a little rough handling en route to market. If the steep slopes are to be utilized—and a large per cent of the mountain land is steeply inclined—something must be planted which will be productive without frequent and intensive cultivation which can but result in later waste and barren land due to the washing away of the upper layers of soil under the tropical downpours.

Few other crops could fit into these conditions as does coffee and it could with difficulty be replaced.

By "coffee" in this circular will be understood *Coffea arabica*, the commonly grown species.

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ALTITUDE FOR COFFEE PRODUCTION.

There is a prevalent opinion that coffee can not be grown very successfully at or near sea level. As a living witness contrary to this general belief there is in the western part ot the Island not far back from the coast a small planting of about 18 acres of coffee planted in land which is very low lying and which was formerly almost swamp. It would be considered excellent cane land. By means of wide and deep ditches the land was thoroughly drained and afterwards planted to coffee. The owner reports that the annual yield from this place averages from 700 to 900 pounds per acre. He has some adjoining fields planted to cane but states that his coffee pays better than his cane and that he is enlarging his coffee plantings.

Though good coffee may be grown near sea level the best plantations in Porto Rico are at some altitude. In Java 1200 ft. is regarded as the lowest elevation at which coffee thrives well and an elevation of from 2000 ft. to 4000 ft. is preferred. In Brazil some of the plateau land on which coffee is grown is so elevated that frost is formed.

SOILS FOR COFFEE.

Under favorable conditions coffee will thrive in a variety of soils. In Java the coffee soils are said to vary from gravel and coarse sand to clay soils of various hues. The best coffee soils of both Java and Brazil are said to be very deep. In a soil survey from Arecibo to Ponce (1) which is thought to include most of the important types of soil found in the Island, the soils reported as best adapted to coffee are the Adjuntas clay, the Alonso clay and the Utuado loam, the first two forming a little more than 20 per cent of the land surveyed. All are residual soils formed by the disintegration and decomposition of igneous or volcanic rocks.

ADJUNTAS CLAY.

The Adjuntas clay is pink, red, or dark brown in color, underlain by a pink or red clay subsoil. It is from 3 to 8 inches deep and the subsoil varies from 20 inches to many feet in depth. It is well supplied with lime and apparently well supplied with nitrogen also,

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but contains only a small amount of phosphoric acid and but traces of potash.

ALONSO CLAY.

The Alonso clay is a dark purplish clay loam with a subsoil which is a heavy tenacious loam of the same color. The upper soil is from 8 to 36 inches deep. It contains pebbles and sometimes large boulders. Though it contains less lime and a trifle less nitrogen than the former yet its supply of nitrogen is good. It contains somewhat more phosphoric acid than the Adjuntas clay and is well supplied with potash.

SEED.

SELECTION.

After the selection of land has been made the first consideration should be the procuring of suitable seed. It has been the custom in Porto Rico to use seedlings from any source whatever. These may have sprung from more or less immature or green fruits from an accidentally broken branch, or from diseased fruits, and the young plants may lack the initial strength and vigor which they should possess. Again they may have come from trees from which it is undesirable to propagate. It is a well known fact that the strongest tendency in any plant is to resemble its parent. For this reason it is most desirable to carefully select those trees which apparently through their own vigor rather than through some accident of surrounding circumstances seem most nearly to resemble the ideal coffee tree. From these trees which most nearly approximate the ideal the seed should be selected.

PREPARATION.

Having been allowed to ripen on the trees the coffee after picking is pulped by hand or by the ordinary coffee pulper in case the latter is not so tightly gauged as to break or crack the seed or in so poor a condition as to prick it. The seed may then be washed in water containing wood ashes to remove the slimy stratum covering the parchment. The light grains which float are found to be mainly parchment covering a shriveled, diseased, or poorly formed seed and should be discarded. If not planted immediately the good seed should be spread out in the shade to dry. Tests made at this

station have shown that properly prepared coffee seed should keep its viability uninjured for about four months. It should not be kept longer than this before planting as, under ordinary conditions in Porto Rico, the percentage of seeds which germinate decreases after this time until after about eight months no seed will germinate.

PLANTING.

The seed may be planted either in boxes or in seed beds. Planting in boxes usually insures a little more care and attention in the preparation of the soil which is quite important. If the planting is to be large it is rather difficult to secure a sufficient number of boxes, and seed beds must be used. The soil should be worked over several times until all clods are broken up and it is in a finely pulverized condition. It is better if the first working is done several weeks or a month before planting. The seed should be gone over again in order to discard any very small, or large and malformed seed as the latter usually contain several germs under one parchment covering. The seed should be planted about 2 inches apart each way. It is first laid on the surface of the soil, the proper spacing being observed, and then pressed in lightly with the finger and a little fine soil put over it, taking care not to cover too deeply. A quarter of an inch is quite a sufficient soil covering for the seed. After planting the soil should be firmed with a board. From very fresh seed some will have germinated in four weeks but for average good seed the majority will take from five to eight weeks to germinate.

NURSERY.

LOCATION AND PREPARATION.

About a month after the seed is planted work should be begun on the nursery beds. Both seed and nursery beds should be located where water is easily available during dry weather. The nursery beds, if suitable locations can be found, should be well distributed over the prospective planting. This is preferable to having the beds grouped in one place or having all of the plants in a few very large beds as in making the permanent plantings labor will be saved in transporting the plants and the chances of injuring them will be lessened. It should be deeply spaded and should be hoed several times until it is in a thoroughly good mechanical

condition. It is well to add about a pound of well rotted manure per square foot, working this well into the soil.

The beds should be so located in regard to surroundings that if covered, the plants may receive fully as much sunlight after the coverings have been removed as any of them will receive when planted in permanent location. Otherwise the transplanting from a shaded to a more or less unshaded location will add to the shock received by the plant.

COVERING FOR BEDS.

Sometimes nursery beds are covered with a sloping roof of palm leaves supported on a frame work leaving sides and ends open. This is easily constructed from poles and palm leaves near at hand. This covering protects the young plants from pelting rains, and in an exposed place it furnishes protection against too many hours of sun which may severely dry out the soil. This covering is removed gradually until by the time the plants have four or five pairs of leaves it has been removed altogether. Young seedlings which are in dense shade are very slow in developing. This was illustrated by two sets of half a dozen pots each planted with coffee which received the same treatment except that one lot was kept in a situation receiving a good share of sun and at all times a large amount of light. The other was in very dense natural shade. A little more than five months after the seed was planted all plants in the first lot had three to four pairs of true leaves. Of the other more than two thirds had developed only cotyledonous leaves. This shade was denser than that which would be found under the ordinary nursery bed covering. But that there is a danger of the shade being too dense for the proper development of seedlings unless careful watch is kept to lighten it is shown by the fact that frequently the growth at the ends and sides of the covered beds is much more vigorous and pronounced than that in the center which has received much light. As soon as it is seen that the plants at either end are outstripping the others more light should immediately be given the more shaded plants.

Frequently suitable locations may be found which are quite sufficiently protected to make the roofing unnecessary.

SIZE OF BEDS.

The size of the beds must of course depend on the number of

plants wanted and the distance apart at which they are set in the nursery bed. Four feet is a convenient width and if the bed is to be covered, two beds may be placed parallel with a run 2 feet wide between them thus allowing both to be covered by the same roof. If the beds are to be made 4 feet wide and the plants are to be set 6 inches apart and 3 inches from each edge, there must be 62.5 ft. of combined length of beds to hold a thousand plants. If the plants are to be spaced at 8 inches rather than 6 the combined length of beds must be 111⅓ feet. It is well to provide from 10 to 20 per cent more plants than the requisite number for the complete planting, as young plants sometimes damp off in the nursery bed, some will lack vigor and must be discarded, and accidents of one sort or another are liable to happen even after the plants have been set out in the field.

DRAINAGE.

If the nursery beds are built up higher than the surrounding land the drainage will be better and the removal of the plants later will be facilitated. The soil may be kept in place by pieces of bamboo or any long pieces of wood fastened in place at the sides of the beds by wooden pegs. If the beds are at the base of a slope or on a slope so that in heavy rains they may be washed over, ditches should be dug just above the beds to carry off the water.

TIME FOR SETTING.

When the plants have developed their first or round cotyledonous leaves they are ready to be set in the nursery bed. This will be from two to three months after the planting of the seed. The soil should be put in good condition and the surface of the bed leveled prior to planting. If the soil is a little dry it should be well sprinkled on the day preceding the setting out.

MARKING OFF AND SPACING.

For marking off a stick having notches at the required distance is very useful and assures the proper spacing of the plants. For plants which are to be removed from the nursery bed the season following their planting, that is within a year from seed, the spacing is sufficient if the plants are set 6 inches apart. If they are to be left until the second season, that is until they are from 1½ to 2

years from seed, they should be set not closer than 8 inches. If the plants are set too closely neither roots nor branches can develop properly.

SETTING IN NURSERY.

The small seedlings may be removed from the seed boxes or bed with trowel or machete or any instrument which will lift them without injuring the roots. Those plants which have feeble and poorly developed root systems should be discarded. If the tap root is rather long it may be slightly shortened with knife or scissors. A small stick will serve to make the holes for planting. The work will be accelerated if a man goes ahead to punch holes at the proper spaces leaving another to pick up and place the plant with one hand and to firm the soil well around it with the other. Unless care is taken that the holes are sufficiently deep the tap root may be turned up and an ugly twist in the root will result before it can resume its normal direction of growth. The young plant should not be set deeper in the nursery bed than it was in the seed bed as deep setting is a factor which is apt to favor damping off or other fungus diseases of the stem.

CARE OF NURSERY.

The nursery bed should be kept clean of weeds and the soil should be lightly dug over at intervals with a spading fork or hand fork, the intervals being shorter as the soil shows a tendency to harden or as the season becomes dry. Keeping the surface soil finely pulverized and well mulched will greatly aid the conservation of moisture in the soil during dry weather. The beds should be watered well when necessary. It is much better to give fewer and more thorough waterings than more frequent waterings of the kind which do little more than sprinkle the surface and simply induce damping off. On the day following a thorough watering which has soaked in well the surface soil should be well stirred to break the crust and retard evaporation.

CLEARING FOR THE COFFEE PLANTING.

The time for beginning the clearing of the future planting must of course depend on how long the plants are to be left in the nursery, how large the planting is to be and how many laborers are to be employed. The land will have to be cleaned of the under-

growth, and the taller growth probably thinned out if it is virgin soil. In cutting out the trees, as far as possible the leguminous trees should be left to furnish the shade and the others removed. Among the most commonly found leguminous trees which are here used for coffee shade are guava, guamá, bucare and moca. If the timber which is cut instead of being burnt or made into charcoal is allowed to remain on the ground a great deal of humus and fertility will be laid up for the coffee trees. Where there is danger of the soil washing, the felled trunks laid at right angles to the slope of the hill will tend to greatly reduce the amount of soil carried off.

Of course the land can be cleared entirely and burnt off and under some conditions this might be advisable, for instance, in case the trees were mostly guamás infested with the ant, *Myrmelachista ambigua Forel subsp. ramulorum Wheeler*, commonly known as "hormiguilla". But by burning, a great deal of valuable humus is destroyed and this should be done only when it is considered necessary for the destruction of some enemy of the coffee.

ROAD MAKING.

After the land is cleared but before staking off for planting, the main roads and the smaller foot paths should be laid out. Making the roads before planting will save laborers' time in going to and from work and will greatly facilitate the necessary overseeing of work. It will obviate any necessity for the later removal of coffee which might have been planted in the roads were they left to be made after planting. Occasionally a plantation of old coffee is seen which in all the years of its existence has never had through it the small footpaths necessary for the speedy passing from one part of the place to another. Each time it is necessary to pass through the coffee the way must be slowly made through tangled growth, up steep slopes and around fallen tree trunks with a loss of time and energy.

DRAINS ON STEEP SLOPES.

Where the slopes are very steep the rains will wash them much less if ditches are placed at intervals not exactly at right angles to the slope but with a gentle and steady incline to natural drains. These should be made before setting the coffee else it would be more difficult to obtain the desired inclination.

STAKING OFF AND SPACING.

The land is now ready to be staked off. In some coffee countries where coffee is grown on level land which can be cultivated by machinery the trees are planted very much farther apart than in Porto Rico where the steep or rolling hillsides would soon suffer severely from erosion were much cultivation attempted. Here it seems that for Arabian coffee a planting distance of 7 to 9 feet is quite sufficient. Setting 7 x 7, 8 x 8, 9 x 9 feet will give respectively 888, 680 and 537 plants per acre. On the Island may be seen plantings of very large and handsome coffee trees set 7 x 7 feet which do not seem crowded though there is no waste space. Still others may be seen with trees which shade well the surface of the ground and do not seem too widely spaced though set 8 to 9 feet apart. In a location well suited to coffee, closer planting than 7 x 7 feet is not advisable as the trees will be cramped for room. To line off to a mathematician's nicety is something of a problem where the lay of the land is so rolling and irregular. Where the slope of the land is fairly regular squares of convenient size may be laid off having tall straight stakes at the desired planting distances around the four sides. The position for the stakes within the square may then be easily ascertained by sighting in the two directions. Where the conformation of the land is more irregular tall stakes may be set at the two ends of parallel and properly spaced lines. Between these stakes may be strectched a wire marked at the places for the intermediate stakes to be set, that is if the land has been entirely cleared. However, if trees have been left, which is both most likely and advisable, the handling of a wire or rope will be found very inconvenient and slow and a stake, in length the desired spacing distance, may be used to space the stakes in the line, each one being measured from the preceding and the line being sighted in one direction only. Fairly straight lines will be of great help in harvesting the crop as thus the man in charge of the pickers can better oversee them than if the trees are set in irregular fashion.

HOLING.

It is well to make the holes at least a month or six weeks before the transplanting to allow the air to work upon the soil. Some planters recommend holes 2 feet cubed and in some sections of the Island these can be made by contract at one cent each. In the stiffer soils the cost would, however, be much above this. These

holes are rather larger than customary but it stands to reason that a thorough preparation of the soil before planting will contribute much to the future well-being of the tree. If the hole is made 2 feet cubed the surface soil should be put above or at the side of the hole where it will be convenient for the later filling. The lower soil should be placed at the lower side of the hole to form a table or individual terrace. If the holes are small the soil should all be placed at the lower side of the hole. If the slope is very steep a few stakes driven in, inclining in the same direction as the slope and having others placed crosswise, will help mold the loose soil until it can settle in its new position. The holes should be filled a week before setting the trees to allow the soil to settle well. A stake should first be put to mark the place for the tree. Then the surface soil from above the hole should be drawn in until the hole is completely filled, the soil being firmed with the feet several times during the process in order to insure the complete filling of the hole. After the filling is finished the soil above should be cut with spade or hoe and drawn to the lower side thus forming a flat table or individual terrace for the tree. . Where stones are available they may be used to great advantage at the lower side of the terrace to prevent washing or loss of soil. Where the inclination is moderate neither sticks nor stones need be used as the soil will not tend so much to wash. Terraces for the trees can be made to best advantage before the trees are set. They need not necessarily be made full size, however, as they can be enlarged as the tree increases in size. The advantages of terraces on inclined land are that the loss of surface soil through washing is reduced and that soil washed from above is frequently deposited on the terrace instead of continuing on its way to the streams in the valley bottoms, and that leaves and small sticks and twigs are also deposited, forming humus; that a tilling of the soil in the vicinity of the tree is made possible which would otherwise result only in a serious loss of soil; and that in case it is desirable to fertilize the trees much more of the fertilizer is conserved for the tree through reduced washing.

METHODS OF TRANSPLANTING.

The transplanting may be done either with roots encased in the clod of earth in which they grew in the nursery or with the root system bare. They may be removed from the nursery in the first rainy season after planting or they may be left until the following. Each method has its own advantages. If it is fairly early in the

rainy season, so much the better as the plants will then be given more time for extending their root systems before the dry weather comes on. A cloudy cool day is much better than a hot sunny one if the plants are to be set without the surrounding clod.

SEEDLINGS WITH 5-6 PAIRS OF LEAVES.

Let us suppose that the coffee trees are set in the permanent planting the first season. They should be left in the nursery until they have 5 to 6 pairs of leaves as plants smaller than this should not be put in the field. They may be taken up with spade or machete, taking care not to injure the root system. The roots should be examined and the less vigorous plants which have poorly developed root systems should be discarded. The others should have the easily bent tip of the tap root clipped with knife or scissors as then it is less liable to be doubled and given an upward turn on setting out. The plants will not dry out so quickly if placed between the folds of a dampened sack. Care should be taken not to expose the roots to the sun as this will dry them very quickly.

The ground having been previously prepared may have holes of proper size to set the plant made by ramming if the soil is not too stiff. A tree limb or trunk of suitable diameter blunt-pointed and about 4 feet long makes a good ram. If this will make it cake badly the hole may be made with trowel or machete. It should be sufficiently deep to allow the roots full extension

The plant should be set so that it will be at the same depth in the permanent planting as in the nursery and the roots should be put in their normal positions. With the hands the soil should be well firmed around the roots as it is put in.

If the transplanting is to be done with roots in the surrounding clod the weather is a less important factor than in the preceding case. There will be needed several shallow boxes and a frame on which to set them having at either side a long pole to serve as handles for two men to carry it by. If the nursery bed has been built up as suggested the supporting framework may be removed and with a narrow spade or with a machete the plants in the outer row may have the soil in which they are growing cut into cubes, a tree marking the center of each upper face. If roots protrude they may be clipped. In many parts of the Island the soil is of such a texture as to hold together well and with careful handling and a slight firming with the hands the cubes will need no support. Where the soil is loamy, banana or other leaves will help hold it in

position. As soon as the outer row has been removed the next is ready to be cut and treated in the same manner. Removing always outside plants makes it a simple matter to get a good cube of soil. The cubes are set in the boxes as soon as they are cut to save as much handling as possible. They are then carried to the prepared holes and set at the same depth as in the nursery, the soil being well firmed around the sides of the cubes.

If the plants are set the first season, say when they have only 5 to 6 pairs of leaves, a careful transplanting in suitable weather of the plants with root systems bare of earth will result fully as well as the much slower, more laborious, and therefore more costly transplanting with the roots encased in the surrounding earth from the nursery bed.

SEEDLINGS LEFT IN NURSERY UNTIL SECOND RAINY SEASON.

If the coffee planter leaves his plants in the nursery bed until the second season, that is until they are 18 - 20 months old from seed, he will greatly reduce his expenses since the keeping in condition of his nursery beds for a year longer is only a small item in comparisonwith the up-keep of the plantation. If this is to be done it is advisable to set the trees 8 inches apart in the nursery rather than 6 inches, as the former spacing will give sufficient room for root and branch development where the closer planting would crowd if conditions are favorable for growing. The plants if left in the nursery until the second season seem thriftier and better able to resist unfavorable circumstances, and a more even stand is consequently obtained. The process of transplanting is the same as described for the younger plants.

In an experimental planting made at this station of plants left in the nursery until the second season, two rows were set under similar conditions except that the one was set with roots bare of earth and the other with roots encased in the surrounding clod. The following season the former produced no coffee while nearly 25 per cent of the trees in the latter produced a few grains, and the average height of the latter was more than 10 inches greater than that of the former. It can be seen that for trees 18 - 20 months old transplanting with roots encased in the surrounding clod is preferable. However, good results may be obtained by careful transplanting with the root system bare. If this plan is followed cloudy days should be selected and the evaporating surface of the tree should be reduced by removing about half of each leaf.

PLANTING OF STUMPS.

By some the cutting back to 6 inch stumps is advised on transplanting if the trunk of the plant has attained the thickness of a lead pencil. If the plants are not very sturdy and more especially if the soil conditions are not very suitable the young plant has trouble in recovering from this severe pruning. If the location is slightly sunny frequent cleanings will be necessary as being so small the coffee renews are soon covered by the rapid growth of weeds, and once slightly concealed are easily injured by careless cleaners. When the young shoots come out they must be gone over several times to remove any superfluous ones, leaving only the one or two renews which are most vigorous.

CARE OF COFFEE AFTER SETTING IN PLANTATION.

CULTIVATION.

As the planting table has presumably been made small at first, before each cultivation it should be enlarged by cutting with spade or hoe soil from above and placing it at the lower side of the terrace. If the individual terraces have been made as suggested the young coffee trees can be cultivated without danger of so much loss of soil. The most advantageous time for cultivation is toward the end of the rainy season or the beginning of the dry before the soil has thoroughly dried out. By keeping a soil mulch around the tree a great deal of moisture will be conserved which would soon be evaporated were the soil not cultivated. If it can be cultivated several times during the early part of the dry season so much the better. Cultivation soon after rains during the dry season will have the same effect. Cultivation will also benefit the plant in other ways than by conserving moisture, namely, making it easier for the small roots to penetrate the soil and by hastening chemical changes which make more plant food available.

In working the soil near the tree care must be taken not to injure the roots. Digging the soil with the ordinary hoe will cut many fine roots but if a hoe with several heavy prongs or a spading fork is used the injury may be greatly lessened.

CLEANING.

As a rule in cleaning steep slopes, machetes are preferable to hoes as with the latter a great deal of the surface soil is pulled

down hill. In the rainy season growth on the slope will greatly lessen erosion but this should all be cut at the beginning of the dry season not only to minimize the amount of evaporating surface but also to act as a leaf mulch, thus saving the moisture for the coffee.

As another means of preventing loss of soil blind ditches may be put in at right angles to the slope. In these will collect leaves and soil loosened by cleaning which would otherwise be carried further down hill by the water.

Where weeds are so numerous as to be objectionable frequent cleanings should be given not allowing seed to form and scatter. The number of weedings must depend on local conditions.

LEGUMINOUS COVER CROPS.

Where the coffee is less shaded and weeds are more troublesome it is an excellent plan to plant a leguminous cover crop at the beginning of the rainy season to be cut when the dry weather begins. Many of the most used cover crops being climbers are unsuitable for coffee on this account. A plant of as dwarf a habit as possible is desirable. The Jack bean, *Canavalia ensiformis*, makes a very thrifty growth and though in shaded places it will climb it may perhaps be hard to find an all around better leguminous cover crop than this for coffee grown under Porto Rican conditions.

PRUNING.

As the coffee trees get older it will be necessary to prune them. Most planters have their own ideas as to how their trees should be pruned. However there are one or two general observations which might profitably be made. The pruning is usually done with machetes. Where the machete is sharp and handled by a man who understands it, a clean, clear cut is made which leaves nothing to be desired. Frequently, however, the limb is cut almost through and then breaks leaving numerous little splinters sticking up and equally numerous little passages leading down. These small passages or pits collect water the first rain and continue collecting water each succeeding rain until the limb or trunk has been rotted with the water far below the point of fracture. If the limb has been cut almost through with machete this breaking may be avoided by finishing up with a saw. The part which has been cut with the saw may then be smoothed over with a sharp knife to leave the whole cut clear and clean. Some limbs are so placed that they

Fig. 1.--Individual terrace or planting table for coffee on hillside.

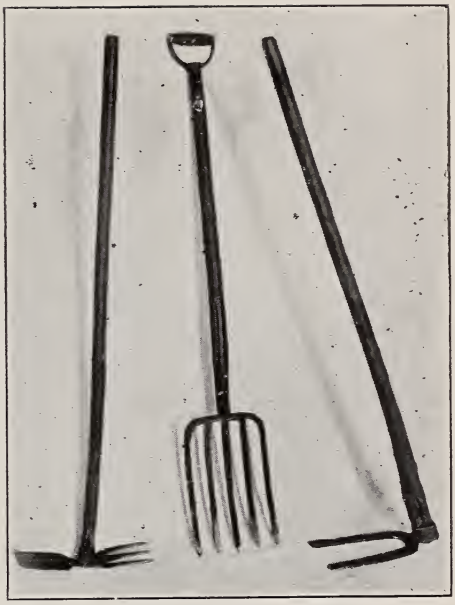


Fig. 2.—Implements useful for cultivating around coffee tree.

Fig. 3.—Good *versus* bad pruning practice.

can not be properly cut with machete. Here the saw and knife alone must be used. All cuts should be made obliquely so that the water will run off rather than stand on and sink into the wound. A coat of ordinary paint over large wounds made in pruning will aid in waterproofing them.

An effort should always be made to keep the growth low. If the trees tend to become leggy they may be made more stocky by topping. If they have already become leggy, that is if they have lost all of their lower lateral branches and only high laterals remain, they should be cut to stump not higher than 6 inches above base if there is only one upright. Where there are several uprights one may be cut low and the others left to be removed later. This cutting will stimulate the tree to force out new uprights with the consequent production of new and lower lateral growth.

FERTILIZERS AT HAND.

In considering the after care of the plantation the saving and using of the fertilizers at hand should not be overlooked.

In the West Indian process of coffee preparation the pulp can be returned quite fresh. By bad handling a large part of the fertilizer from this source is frequently lost. The following partial analysis (a) showing the amounts of nitrogen, phosphoric acid and potash as contained in 3880 kilograms of coffee cherries may be instructive.

PARTIAL ANALYSIS OF COFFEE.

	3880 kgr. of entire cherries.	1000 kgr. of export coffee derived from 3880 kgr. of cherries.	Parchment and pulp derived from 3880 kgr. of cherries.
Phosphoric acid	3 974 kgr. or .10%	2.897 kgr. or .07%	1.077 kgr. or .03%
Potash	28.720 „ „ .74 „	14.441 „ „ .37 „	14.279 „ „ .37 „
Nitrogen	23.856 „ „ .61 „	16.800 „ „ .43 „	7.026 „ „ .18 „

From this table we derive the following:

AMOUNTS OF NITROGEN, PHOSPHORIC ACID AND POTASH REMOVED PER 100 Lbs. OF MARKET COFFEE.

	Entire cherry	Market coffee	Parchment and pulp
Phosphoric acid	.40 lb	.29 lb.	.11 lb
Potash	2.87 „	1.44 „	1.43 „
Nitrogen	2.39 „	1.68 „	.70 „

(a) Le Cafe, H. Lecomte, page 55.
Les Plantes Tropicales de Grande Culture, E. de Wildeman, page 77.

From this it may be seen that were it possible to return to the land all save the actual amount of fertilizer removed by the grain itself, more than ¼ of the total phosphoric acid, nearly ½ of the total potash and considerably more than ¼ of the total nitrogen removed by the crop might be returned to the soil. There will of necessity be losses of fertilizer but these should be reduced as much as possible by the return of the pulp to the soil immediately after coffee pulping. On many plantations back of the pulping house will be found a large pile of fermenting pulp exposed to the full heat of the sun and the full force of the almost daily rains, thus losing a large part of both its nitrogen and its very quickly soluble potash.

On many plantations large numbers of pack animals are kept and consequently stable manure is to be had in considerable quantities. From this as from the coffee pulp large quantities of valuable fertilizer material, soluble ammonia and potash compounds, are frequently lost by mismanagement. The manure from the stables should not be thrown out in a pile exposed to sun and rain until a convenient time is found for applying it, as is frequently the case. The sooner it is applied to the land, the smaller will be the loss. If it is impracticable to apply it as it is removed from the stable, it should be kept closely compacted in a covered non-leakable tank or pit. If possible it should be so arranged as to receive the liquid manure also, the value of which is frequently not appreciated. Though the composition of the excreta may vary with the food and age of the animal the following table (a) gives an average which may serve for comparison.

COMPOSITION OF URINE AND EXCRETA OF HORSE

Excreta	Water	Nitrogen	Posphoric Acid	Potash
Solid	75.0	0.56	0.35	0.1
Liquid	90.0	1.52	trace.	0.92

Where the coffee is planted on terraced land the manure should be spread evenly around the tree and incorporated with the surface soil. Where the land is inclined and not terraced holes or short trenches may be made above the trees and in these the manure composted.

(a) Fertilizers and Manures, Hall. page 181.

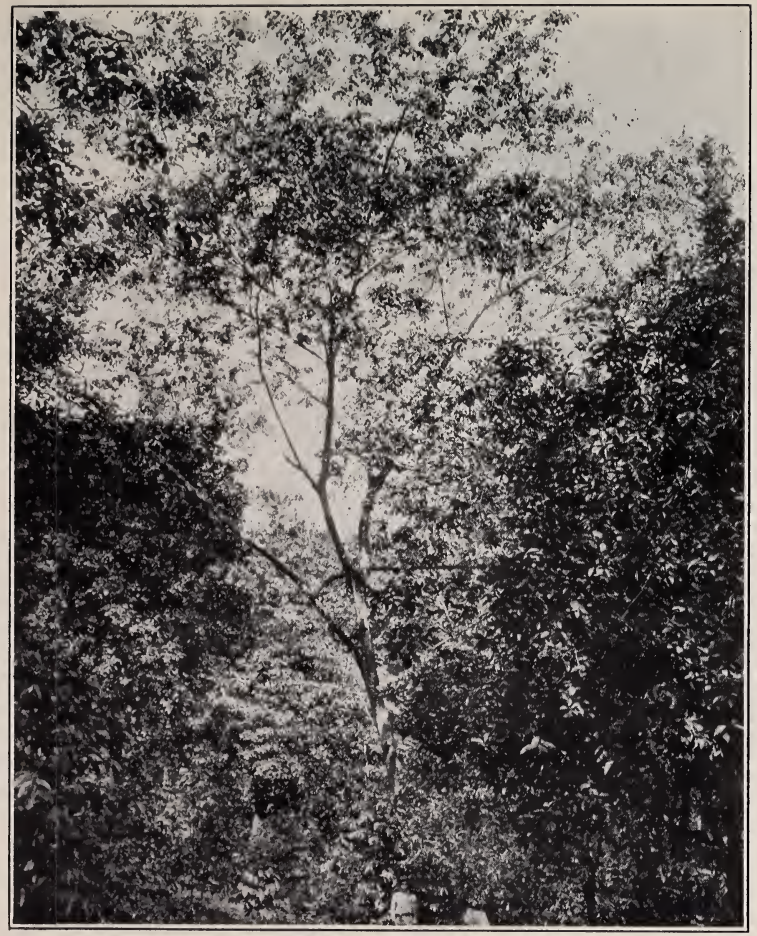


Fig. 1.—Guava, *Inga vera*.

Fig. 2.—Guamá. *Inga laurina*.

The leguminous trees most commonly used for coffee shade in Porto Rico.

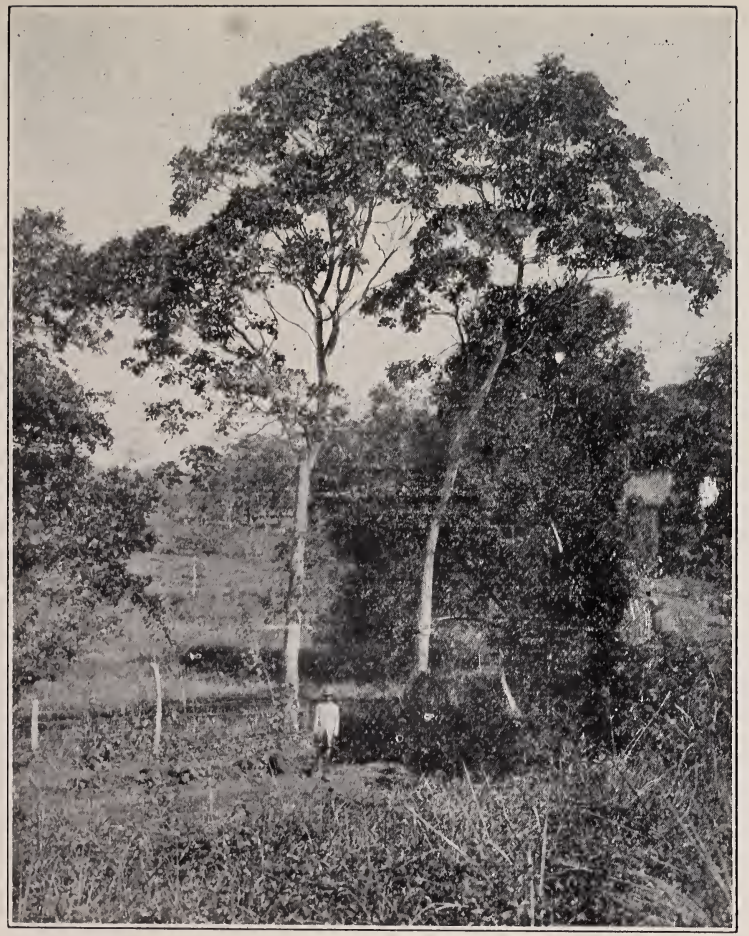


Fig. 1.—Bucare. *Erythrina sp.*

Fig. 2.—Moca. *Andira inermis.*

The leguminous trees most commonly used for coffee shade in Porto Rico.

SHADE.

ADVISABILITY OF SHADE TREES.

For the successful growing of coffee in the Porto Rican hills the use of shade trees seems most advisable. Their mission as windbreaks is by no means unimportant. In the primary preparation of land all exposed ridges should be left thickly wooded, at least a narrow strip along the crest of the ridge if no more. Also trees should be left along the main drains that their roots may reinforce the soil against washing. Trees through the coffee are aids against erosion by breaking with their leaves the heavy fall of rain and by binding the soil with their roots. By the dropping of their leaves the supply of humus is increased. As the coffee leaves are not deciduous and as the humus content of some of the clay soils here is very deficient this is an important function which the shade trees perform.

Care must be taken that the shade does not become too dense. This mistake is easy to make as under dense shade the coffee will be most luxuriant in appearance but it is more or less deceptive as to the yield which is apt to be small. When this is the case the shade should be thinned.

LEGUMINOUS SHADE TREES.

Leguminous shade trees should be used as these are able to draw a part of their nitrogen from the air which is around and between the tiny soil particles, and are thus not dependent on the soil alone for this element.

Among the important leguminous shade trees of the Island may be mentioned:

Guava (a) *Inga vera.* This is the most used coffee shade and seems justly the most popular as its spreading and open form gives a light and evenly distributed shade. It makes a rather rapid growth and may be planted simultaneously with the coffee. If this is done the shade trees should be planted rather close together. A good plan is to set them at twice the planting distance of the coffee trees, always letting the shade tree fall in the center of a square formed by four coffee trees. By the time the coffee is old enough to bear well the shade furnished by this method of planting will be amply sufficient. It will have to be watched, however, as being so thickly set the shade may easily become too dense and first limbs then alternate trees must be removed to avoid this.

(a) This should not be confounded with the fruit guava, *Psidium guajava.*

Guamá. *Inga laurina.* In some parts of the Island this is much used but as it makes a denser shade and is less spreading in form than the former it is less desirable as a shade tree but more desirable as a wind-break. It is a favorite host plant for a large pink scale which furnishes food for an ant, *Myrmelachista ambigua Forel subsp. ramulorum Wheeler,* locally called "hormiguilla", which is most ruinous to coffee trees. In any district where the coffee or guamá trees are known to have this ant, this shade should be watched with care and sparingly planted if planted at all.

Bucare, *Erythrina sp.* This tree makes a very rapid growth and may be grown from cuttings or seed. In some sections it is frequently seen as a shade tree for coffee. It has the objectionable habit of dropping limbs which injure growth below and knock off coffee cherries. Also its large buttresses and large superficial roots take up a great deal of ground, much more in proportion to the spread of limbs than do the other trees used as shade.

Moca, *Andira inermis.* This tree makes a very slow growth and if it is to be planted as shade a faster growing tree must be put in to serve until this can come on. Its form is frequently undesirable being closely headed rather than spreading. As the wood is strong the coffee below is not troubled by falling branches.

TEMPORARY SHADE.

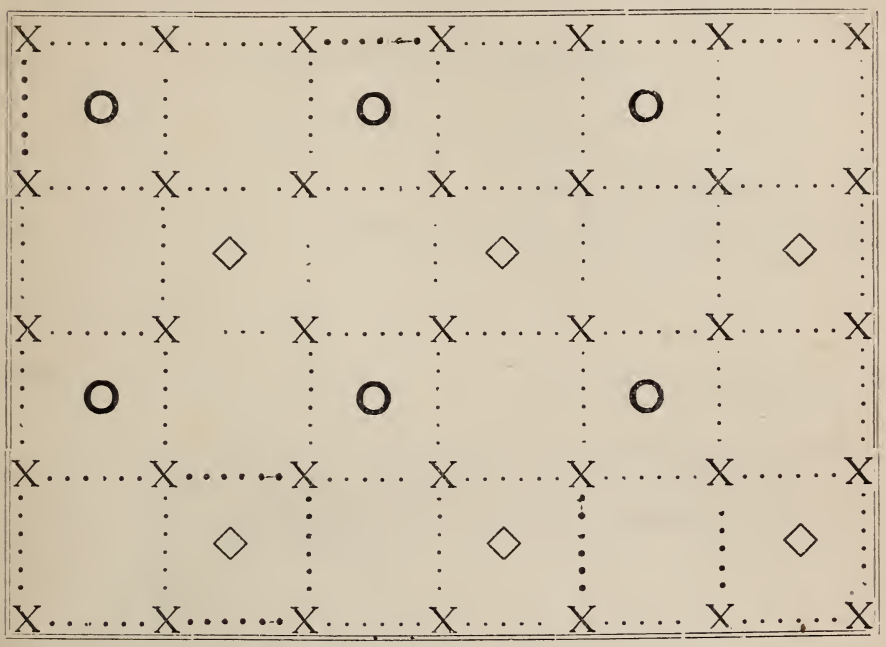
Occasionally a planter wishes to put in coffee a piece of land which is destitute of all shade trees. In this case he should plant something which will grow much more rapidly than his permanent shade and which will afford some shade and protection until his permanent shade can come on. A small and rapid growing leguminous tree which gives a very light and open shade is *Agati grandiflora,* locally known as "gallito". As a wind protection the banana is better than this. It gives a denser shade and thus helps in the struggle against grass and weeds. It also brings in returns until the coffee comes on. However, methods of planting bananas are frequently bad as they are sometimes seen placed immediately at the side of the young coffee trees thus making an unequal struggle for existence between a small slow growing plant and one of coarse and rapid growth. This can only result in detriment to the coffee. The following plan of planting is suggested where bananas are to be used as temporary shade. In case Agati is to be used one or two may be put in the center of each square made by four coffee trees as the Agati gives much lighter shade than the banana and

Fig. 2,—Gallito, *Agati grandiflora*. as temporary shade for coffee, 8½ months from seed.

Fig. 1.—Banana as temporary shade for coffe, 8½ months from planting.

many more will be needed. The coffee trees are represented by crosses; the permanent shade trees, to be thinned later, by circles; and the bananas by squares.

PLAN OF PLANTING COFFEE AND SHADE.



SUMMARY OF EXPENSES PER ACRE FOR FIRST THREE YEARS OF YOUNG PLANTATION.

The following extracts from the reports of J. W. van Leenhoff as published in the annual reports of this station are quite instructive as they come from a former coffee planter of long experience. Local conditions of course will alter one item or another. Mr. van Leenhoff found the expenses and returns per acre for the first three years of a new planting to be as follows:

EXPENSES FOR FIRST YEAR.

Felling forest and burning	$11.00
Lining in, distances 7x7 ft.	2.00
Making 888 plant holes 2x2x2 ft. at $10 per M.	8.88
Filling of 888 plant holes, at $10 per M.	8.88
Seeds and nursery beds for 880 plants ready for planting	5.00
Planting, transporting, etc. at $10 per M.	8.88
Shade-tree seedlings and planting	1.50

Two hoeings, 1 ft. radius in a circle around the tree at $5 per M. each	8.88
Four weedings, at $1.50 per M. each	5.32
Total cost of 888 plants, corresponding to 1 acre at end of first year	$60.34

EXPENSES FOR SECOND YEAR 15.54

EXPENSES FOR THIRD YEAR.

Five weedings at $1.33⅓	$6.67
Repairing damage after storm, estimated	3.00
One hoeing between rows	4.44
	$14.11

Total expenses, three years	$89.99

There was gathered the third year:	
80 pounds of coffee, worth $10.65 per 100 lbs.	$8.52
Less picking, preparing and transporting.	2.23
	$6.29
Net cost per acre to the end of third year.	$83.70